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BIOLOGICAL EFFECTS OF WASTES DISCHARGED TO THE NORTH PLATTE RIVER IN THE TORRINGTON WYOMING TO BRIDGEPORT, NEBRASKA REACH NOVEMBER 1960-NOVEMBER 1961

PUBLIC HEALTH SERVICE, KANSAS CITY, MISSOURI

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Collections and field observations to evaluate the biological effects of wastes discharged to the North Platte River by beet sugar factories in the Torrington, Wyoming to Bayard, Nebraska reach, were made in November, 1960, and August-November, 1961. Data acquired in the November, 1960, and August-September, 1961 investigations were presented to the first session of the conference in Scottsbluff, Nebraska, September 12, 1961, and enters into this report only as needed to supplement later observations or enhance interpretations. Permissible evaluations of biological damage at this point relate to the fish population and its basic food organisms.

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Biological Effects of Wastes Discharged to the North Platte River in the Torrington, Wyoming to Bridgeport, Nebraska Reach, November 1960 - November 1961

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Collections and field observations to evaluate the biological effects of wastes discharged to the North Platte River by beet sugar factories in the Torrington, Wyoming to Bayard, Nebraska reach, were made on November 16 and 17, 1960; August 30 - September 1; October 4, 5, 6, 10, 11, 14, 15, 30, 31, and November 1 and 2, 1961. Information acquired in the November, 1960 and August - September, 1961, investigations was presented to the first session of this Conference in Scottsbluff, Nebraska, September 12, 1961, and will enter into this report only as needed to supplement later observations or enhance interpretations. In 1960, studies covered the reach from above Torrington to Morrill, Nebraska, but all later investigations extended from Torrington, Wyoming to Bridgeport, Nebraska. Station numbers and locations were as follows:

Station	Location	River Mile Above Mouth
1	Torrington, Wyoming Bridge	208.5
2L	Left Side of River, 1 mile Below Station 1	207.5

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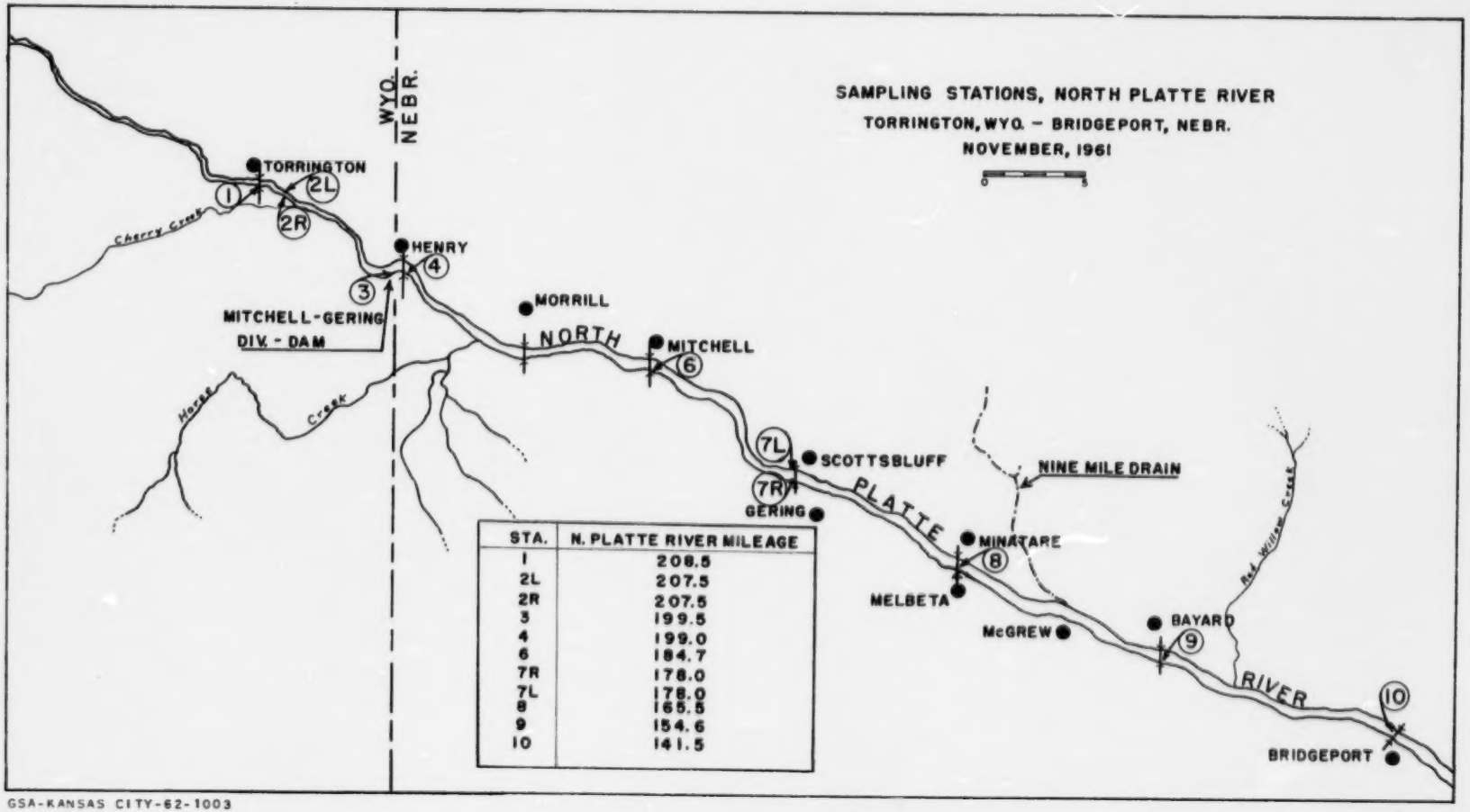
Station	Location	River Mile Above Mouth
2R	Right Side of River	207.5
	as Above	
3	Gering - Mitchell Diversion Dam	199.5
4	Henry, Nebraska Bridge	199
6	Mitchell, Nebraska Bridge	184.7
7R	Right Channel West Scottsbluff, Nebraska Bridge	178.0
7L	Left Channel at Above	178.0
8	Minatare - Melbeta Bridge	165.5
9	Bayard, Nebraska Bridge	154.6
10	Bridgeport, Nebraska Bridge	141.5



STA.	N. PLATTE RIVER MILEAGE
1	208.5
2L	207.5
2R	207.5
3	199.5
4	199.0
6	184.7
7R	178.0
7L	178.0
8	165.5
9	154.6
10	141.5

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RIVER CONDITIONS

Stream Bed Materials

Bottom of this reach of the North Platte River is largely sand. Driftwood accumulations occur at several bridges and diversion dams, and pieces of wood are caught in the sand in many areas. Rocks and gravel are exposed for a few miles below Torrington (an old coffer dam is still in place below the bridge).

In November 1960, fresh accumulations of sugar beet tops, cossettes, pulp, and other particles were common down to the vicinity of Morrill, Nebraska. A photo showing quantities of such materials recovered from one Pettersen dredge haul at Henry, Nebraska was included in material presented to the conferees September 12, 1961. In August 1961, the only evidences of such materials were a few silt covered deposits or "sludge banks" in the area below Torrington, near the Henry bridge, and above the Mitchell bridge. The fate of the great masses of beet particles seen in 1960 is unknown, but it seems reasonable to assume that they were moved on downstream as part of the bed load. Beet parts were much less noticeable in October and November 1961 - tops were seen floating downstream from time to time and suspended pulp was evident for some distance below Torrington, but no deposits (other than scattered bits of pulp, etc., along the right bank below Torrington) were noted anywhere. Silt settled from beet waste onto the rocky bottom below Torrington each year. It was not as easily recognized on sand bottoms farther downstream.

The North Platte stream bed contains numerous small islands or "towheads" that separate flow into two or more channels at most localities.

The presence of these anastomosing and branching streams may permit isolation of tributary or waste discharges for varying distances. Areas investigated in these studies often exhibited distinct differences in water quality in individual channels, but water appearance tended to become more uniform with increasing distance below each sugar beet processing area. Some mention of channeling and water quality differences will appear in the following account.

Discharge

Volume of flow at selected stations during times of these studies is shown in Table 1. Discharge in the fall of 1961 generally exceeded that of November 1960, and greater quantities of water played some role in turbidity reductions noted in the upper reach below Torrington. August and September flows represent the residual from irrigation withdrawals plus quantities added from return flows (drains).

Table 1.
Discharge, cfs, at Selected Sites, North Platte River

	Sta. 1	Sta. 3	Sta. 6	Sta. 8 Main Channel	Sta. 10 Main Channel
November 16, 1960	260	290			
November 17, 1960	254	284			
August 30, 1961			111		67
August 31, 1961			114		
September 1, 1961			136		
October 4, 1961	370	235			1040
October 5, 1961	375	240			
October 6, 1961	370	235		437	
October 10, 1961	360	392	557		
October 11, 1961	340	368			
October 14, 1961	330	362			
October 15, 1961	330	362			1186
October 30, 1961	320	350			
October 31, 1961	315	344			
November 1, 1961	320	350			
November 2, 1961					

Water Appearance

On all visits water was clear at Station 1. In November, 1960, discharges from the Torrington beet factory discolored about one-half of the river down to the region of Station 3. Flow through the control channel just below the Gering - Mitchell Ditch gate mixed the turbid beet wastes into all discharge; and the entire river was dingy brown or gray in appearance from there down to Morrill. In late August and early September, 1961, the river remained clear down to the mouth of Kotzer Drain, about 1/4 mile above the Gering - Mitchell Ditch. Muddy water from the drain colored a narrow strip of water along the right bank (most of it entered the ditch) and the river was slightly dingy at Station 4. A low turbidity was then maintained down to the vicinity of Scottsbluff. A sharp increase noted at the Minatare - Melbeta bridge gradually faded out and the stream was but slightly discolored at Bayard and Bridgeport. In October and November, 1961, conditions of the preceding autumn were largely duplicated. Discharge was somewhat higher and some suspended matter was carried over to the left bank within the first mile below the Torrington beet waste outfall. However, distinct differences in turbidity, left and right, were usually maintained down to Station 3, where complete mixing again occurred. Some fluctuations were noted, but turbidity was maintained at high levels (but lower than in 1960) all the way to Bridgeport and below. Important contributions came from sugar plants at Mitchell, in the Scottsbluff area, and at Bayard, but suspended matter also entered from irrigation drains. In August, 1961, a small segment of flow was briefly discolored by entrance of sanitary sewage from the Torrington beet plant.

BIOLOGICAL FEATURES

Attached Vegetation

In November, 1960, benthic algae were abundant on firm bottom materials (stones, wood, etc.) in the area above the Torrington beet discharge and on stones near the left bank for some distance below. No such growths were evident near the right bank in this region or anywhere in the river in areas visited below the Gering - Mitchell Ditch. In late August and early September, 1961, algae were attached to all suitable substrates at all collecting stations. Dominance varied from place to place but Cladophora, a green alga, was the major growth in most areas. Other green algae attaining dominance were Microspora, Spirogyra, Rhizoclonium, Oedogonium, and Hydrodictyon. A red alga, Compsopogon, formed almost the entire algal crop near the Henry bridge, and a diatom, Diatoma vulgare, formed part of the dominant growth at the Mitchell bridge.

In late October and early November, 1961, attached algae were found at Stations 1, 2L, 4, 6, 7, and 9. Cladophora and Diatoma vulgare were dominant at most sites visited. Compsopogon was the major growth at Mitchell (Station 6) and in some areas near the West Scottsbluff Bridge (Station 7). The filamentous bacterium Sphaerotilus, commonly called "sewage fungus," was very much in evidence at this time. It shared the bottom with algae at Stations 2L, 4, 6, 7, and 9, and was the only growth present at Stations 2R, 3, and 8. Detached masses, patches, and strands floated downstream in great profusion at Stations 3, 4, and 8, and were by no means rare at other collecting sites. No Sphaerotilus was observed in November, 1960, and in August and early September, 1961, it was seen

only in the very small area crossed by undiluted sanitary sewage from the Torrington beet factory. It must be assumed that widespread growth of Sphaerotilus in the fall of 1961 was made possible by carbohydrates contained in beet sugar wastes. Its absence on November 16 and 17, 1960, when the same wastes were in the river, probably represented restrictive influences of greater turbidity. Sphaerotilus is adversely affected by turbidity increases and may completely disappear for varying periods of time following entrance of any appreciable surface runoff.

Aquatic flowering plants (Potamogeton spp.) were observed at Torrington, Station 2L, the Gering - Mitchell diversion dam, Mitchell, West Scottsbluff, Bayard, and Bridgeport. They were more noticeable in August and September, 1961, than during the previous or following autumn, but conditions developed by sugar beet wastes did not favor their observation.

Attached algae and rooted aquatic plants are utilized directly as food by some fishes and a number of bottom animals, and in this manner serve as the basic link of food chains for other fishes and some other aquatic vertebrates. Conditions restricting their areas of growth can substantially reduce overall biological productivity.

Bottom Animals

In November, 1960, these benthic organisms were present in considerable numbers and variety in the region immediately above the Torrington beet factory outfall and in the left half of the river for some distance below. Only midge larvae and sludge worms were found under the beet wastes that occupied the right half of the stream down to the Gering-Mitchell Ditch and the entire stream from there to Morrill. These latter types are notably

tolerant of organic pollution. In late summer (August - September) of 1961 the barren areas of the preceding November had been repopulated by a number of organisms. The most abundant animal contributing to this new population was a mayfly, Heptagenia diabasia, whose nymphs occupied driftwood at all sites examined from Torrington to Bridgeport. These nymphs were the only organisms found in the vicinity of the Minatare - Melbeta bridge (Station 8). Other bottom dwellers that returned to previously depopulated areas were flatworms, scuds, stoneflies, four other mayflies, damsel flies, creeping water bugs, and black flies. As would be expected, barren areas nearest survival regions remaining in the fall of 1960 were "reseeded" with the greatest number of forms. The right half of the river below Torrington developed 12 forms in addition to the midge larvae found there in November, 1960. The area around the Henry bridge developed only six new forms.

The above observations suggested that depletion of bottom inhabitants in areas coming under the influence of sugar beet wastes is an annual occurrence. Some recovery is apparently possible each year, but opportunity for repopulation by a number of forms declines with distance below unaffected water, which seemingly ends when all flow paths are mixed in passage through the control channel at the Gering - Mitchell Ditch. Insects, such as mayflies, that embark upon long egg-laying flights, are most capable of repopulating more remote reaches.

In the fall of 1961, collections and field observations were planned to ascertain what actions of sugar beet wastes were responsible for the decimation of benthos and how much time was required. The campaign began around October 1 and collections were resumed October 4. Organisms recovered through November 2 are shown in Table 2. Benthic animals were

Table 2.
NORTH PLATTE RIVER BENTHOS
October and November, 1961

9a

Station 1		Station 2L				Station 2R				Station 3				Station 4				Station 6			
10/4	10/30	10/4	10/10	10/14	10/31	10/4	10/10	10/14	10/31	10/5	10/10	10/14	10/31	10/5	10/10	10/14	10/31	10/5	10/10	10/14	11/1
								N	N												
x	x	x	x	x		x		O	O	x	x	x	x	x	x		N				
																	O				
								O	O												
x		x				x		R	R	x							O				
			x					G	G	x							R				
	x							A	A								G				
								N	N								A				
								I	I								N				
x			x	x	x			S	S	x	x			x	x	x	I				
								M	M								S	x		x	
								S	S								M				
																	S				
					x	x		F	F	x		x	x	x	x	x	F	x	x	x	x
								O	O								O				
								U	U								U				
								N	N								N				
								D	D								D				
x	x									x											
										x											
x		x	x	x		x				x	x	x		x	x	x			x		x
x	x	x	x	x						x	x	x		x	x	x		x	x		
		x													x						
x	x									x		x		x	x	x		x	x	x	x
x	x	x	x	x		x															
		x	x	x						x					x			x	x		
										x				x							
										x											
x																					
		x	x																		

Table 2.
NORTH PLATTE RIVER BENTHOS
October and November, 1961

9b

	Station 6			Station 7					Station 8			Station 9			Wild Horse Drain	Station	
		R 11/1		10/6	10/11	10/14	L 11/1	R 11/1	10/6	10/15	11/1	10/6	10/14	11/1	11/2	10/6	10/15
Platyhelminthes											N						
Dugesia sp.						x					O						
Annelida																	
Leeches											O						
Nephelopsis sp.				x							R				x		
Sludge Worms											G						
Aquatic Earthworms											A				x		
Mollusca											N						
Snails											I						
Physa sp.				x		x	x		x		S		x				
Lymnaea sp.					x					x	M						
Crustacea											S						
Scuds																	
Hyalella azteca		x		x	x	x	x		x	x	F	x	x				
Sow Bugs											O						
Asellus militaris											U				x		
Asellus brevicaudus											N				x		
Crayfish											D						
Orconectes virilis				x													x
Insects																	
Stoneflies																	
Perlesta placida																	
Acroneuria sp.																	
Mayflies																	
Tricorythodes sp.				x								x					x
Heptagenia diabasia				x	x	x	x		x	x		x	x			x	
Heptagenia flavescens																	
Baetis spp.		x		x	x	x	x	x	x	x		x	x			x	x
Pseudocloeon sp.																	
Centroptilum sp.															x		
Isonychia sp.																	
Hexagenia limbata																	
Traverella sp.																	
Choroterpes sp.																	

Table 2.
NORTH PLATTE RIVER BENTHOS
October and November, 1961

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	Station 6		Station 7					Station 8			Station 9			Wild Horse Drain	Station 10			Drain 2
	R 11/1		10/6	10/11	10/14	L 11/1	R 11/1	10/6	10/15	11/1	10/6	10/14	11/1	11/2	10/6	10/15	11/2	11/2
										N							C	
					x					O							O	
																	L	
										O							L	
			x							R				x			E	
										G							C	
										A				x			T	
										N							I	
										I							O	
			x		x	x		x		S		x					N	x
				x					x	M								x
										S							I	
																	M	
	x		x	x	x	x		x	x	F	x	x					P	
										O							O	
s										U				x			S	
dus										N				x			S	
										D							I	
ls			x													x	B	
																	L	
																	E	
			x								x					x		
sia			x	x	x	x		x	x		x	x			x			
scens																		
	x		x	x	x	x	x	x	x		x	x			x	x		
														x				x

Table 2.
NORTH PLATTE RIVER BENTHOS
October and November, 1961

Station 1		Station 2L				Station 2R				Station 3				Station 4				Station 6			
10/4	10/30	10/4	10/10	10/14	10/31	10/4	10/10	10/14	10/31	10/5	10/10	10/14	10/31	10/5	10/10	10/14	10/31	10/5	10/10	10/14	L 11/1
								N	N								N				
								O	O								O				
x	x	x	x	x	x	x				x	x	x		x	x						
x		x		x	x	x		O	O	x		x		x			O		x		
x		x	x	x	x	x		R	R	x				x	x		R				
								G	G								G				
x		x						A	A	x	x			x			A				
								N	N								N				
x		x	x	x		x		I	I	x	x	x		x	x		I				
x			x					S	S			x		x	x	x	S	x	x		
								M	M			x					M				
								S	S					x			S				
								F	F								F				
x	x	x	x	x	x	x	x	O	O	x	x	x	x	x		x	O				x
		x		x	x			U	U								U				
						x		N	N			x		x			N				
								D	D	x				x			D				
		x	x							x		x									
			x											x							
										x		x									
	x																				
x	x	x				x				x	x	x		x	x	x			x	x	x
				x						x											
x	x														x						x
	x		x															x		x	x

9c

Table 2.
NORTH PLATTE RIVER BENTHOS
October and November, 1961

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	Station 6			Station 7					Station 8			Station 9			Wild Horse Drain	Stati	
		R 11/1		10/6	10/11	10/14	L 11/1	R 11/1	10/6	10/15	11/1	10/6	10/14	11/1	11/2	10/6	10/
Insects (cont'd)																	
Damsel flies											N						
Argia sp.							x				O						
Amphiagrion sp.		x										x					
Hetaerina sp.											O						
Dragon flies											R						
Ophiogomphus sp.											G						
Bugs											A						
Ambrysus sp.											N						
Sigara spp.					x			x			I	x	x				x
Ranatra sp.											S						
Notanecta undulata											M						
Lethocerus americanus						x					S						
Caddis flies																	
Hydropsyche aerata											F						
Hydropsyche bifida gr.											O						
Cheumatopsyche sp.											U						
Leptocella diarina											N						
Limnephilus consocius											D						
Beetles																	
Laccophilus sp.																	
Agabinus sp.																	
Tropisternus sp.																	
Gyrinus sp.																	
Elmidae sp.									x								
Flies																	
Blackflies																	
Simulium (Neosimulium --vittatum)																	
Simuliidae spp.		x		x	x			x				x				x	
Midges																	
Pentaneuria sp.																	
Spaniotoma nivoriunda																	
Spaniotoma spp.		x					x	x	x	x		x	x	x	x		x

Table 2.
NORTH PLATTE RIVER BENTHOS
October and November, 1961

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	Station 6			Station 7					Station 8			Station 9			Wild Horse Drain	Station 10			Drain 2
		R					L	R											
		11/1		10/6	10/11	10/14	11/1	11/1	10/6	10/15	11/1	10/6	10/14	11/1	11/2	10/6	10/15	11/2	11/2
)																			
											N							C	
							x				O							O	
1 sp.		x										x						L	
ip.											O							L	
is sp.											R							E	
											G							C	
).											A							T	
											N							I	
					x			x			I	x	x				x	O	
											S							N	
ndulata											M								
americanus						x					S							I	
																		M	
e aerata											F							P	
e bifida gr.											O							O	
che sp.											U							S	
diarina											N							S	
consocius											D							I	x
sp.																		B	
).																		L	
ia sp.																		E	x
									x										
Neosimulium																			
spp.		x		x	x			x				x				x			
sp.																			
nivoriunda																			
spp.		x					x	x	x	x		x	x	x	x		x		

Table 2.
NORTH PLATTE RIVER BENTHOS
October and November, 1961

Station 1		Station 2L				Station 2R				Station 3				Station 4				Station 6			
10/4	10/30	10/4	10/10	10/14	10/31	10/4	10/10	10/14	10/31	10/5	10/10	10/14	10/31	10/5	10/10	10/14	10/31	10/5	10/10	10/14	11/1 L
								NO													
	x																				
								ORG													
			x	x				ANI			x										x
								SMS				x									
		x				x				x	x									x	
																					x
								FOUND													

Table 2.
NORTH PLATTE RIVER BENTHOS
October and November, 1961

	Station 6			Station 7					Station 8			Station 9			Wild Horse Drain	Stat	
		R 11/1		10/6	10/11	10/14	L 11/1	R 11/1	10/6	10/15	11/1	10/6	10/14	11/1	11/2	10/6	10
Insects (cont'd)																	
Midges (cont'd)																	
Cardiocladius obscurus																	
Chironomus (Sticto.)												x					
--flavincingula																	
Chironomus (Limno.)																	
--modestus or fumidus		x		x													
Chironomus (Endo.)																	
--nigricans																	
Chironomus (Chironomus)																x	
--militaris																	
Anthomyiidae															x		
Limnophora aequifrons																	
Miscellaneous			•														
Nematodes		x															

Note: No organisms were found in Drain 1 November 2, 1961.

Table 2.
NORTH PLATTE RIVER BENTHOS
October and November, 1961

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	Station 6		Station 7					Station 8			Station 9			Wild Horse Drain	Station 10			Drain 2
	R 11/1		10/6	10/11	10/14	L 11/1	R 11/1	10/6	10/15	11/1	10/6	10/14	11/1	11/2	10/6	10/15	11/2	11/2
curus p.)											x							
idus	x		x															
homus)															x	x		
rons														x				
	x																	

e found in Drain 1 November 2, 1961.

virtually eliminated from the right half of the river one mile below Torrington by October 10, and none could be found on October 14 or later. Organisms disappeared at Henry before October 31, and before November 1 at the Minatare - Melbeta bridge. Bayard was reduced to one form of midge larva before November 1. Persistence of some organisms at Mitchell seemingly indicates some recovery from Torrington beet wastes, and it appeared that conditions at the West Scottsbluff bridge (Station 7) were improved by some retention of flow in a gravel pit just upstream. Numbers of organisms and variety of forms were reduced at these two localities. With these two exceptions, it appears that the sugar beet industry eliminates bottom organisms in all river reaches between the Gering - Mitchell diversion dam and Bridgeport; and less than one month is required for realization of this condition.

Study of organisms taken at intervals during the month of October indicated that death of most was due to an indirect effect of sugar beet wastes--stimulation of Sphaerotilus growth. Figures 1, 2, and 3 show the condition of mayfly nymphs (Heptagenia diabasia) from near the Henry bridge at varying periods of time after start of the beet campaign. Figure 1 shows a nymph without Sphaerotilus growth (October 6), Figure 2 indicates the beginning of bacterial attachment, and Figure 3 is a photo of a nymph completely swaddled and restricted by Sphaerotilus filaments (October 14). Death usually follows development of this condition. Dead mayfly nymphs were observed at Stations 3, 6, 8, and 9 on October 14 and 15.

The North Platte was noticeably more turbid in November of 1960 than in October and early November 1961, and, since Sphaerotilus was absent during the 1960 visit, processes involved in elimination of benthos by that beet campaign may not safely be attributed to this bacterium, although there

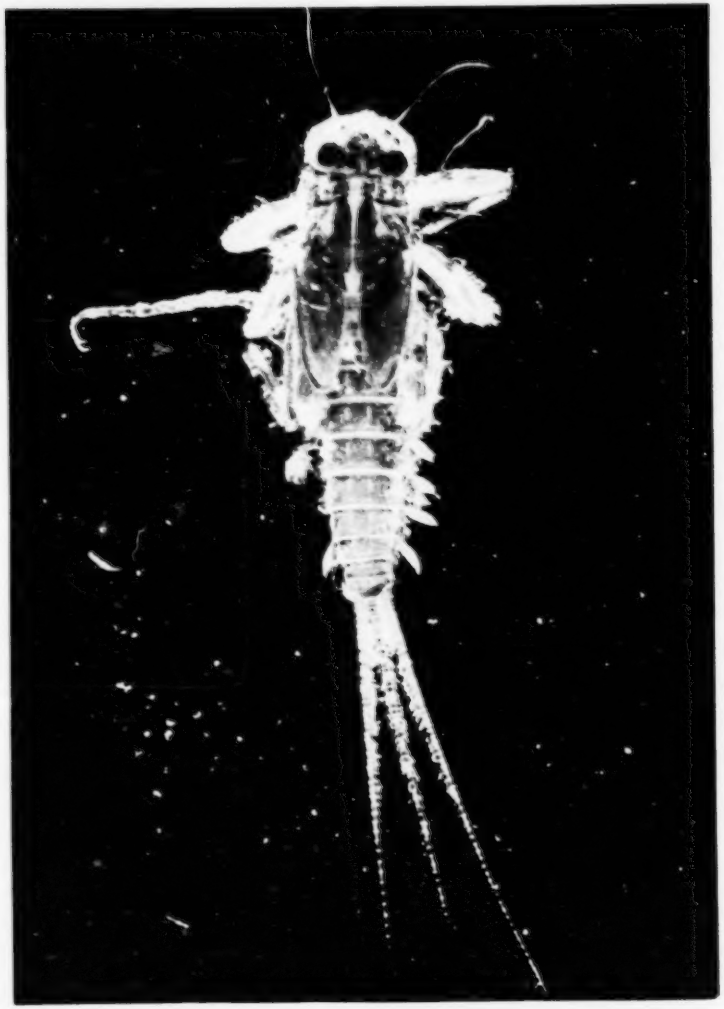

Fig. 2. Mayfly nymph with beginnings of Sphaerotilus growth. Sta. 4, October 10, 1961.

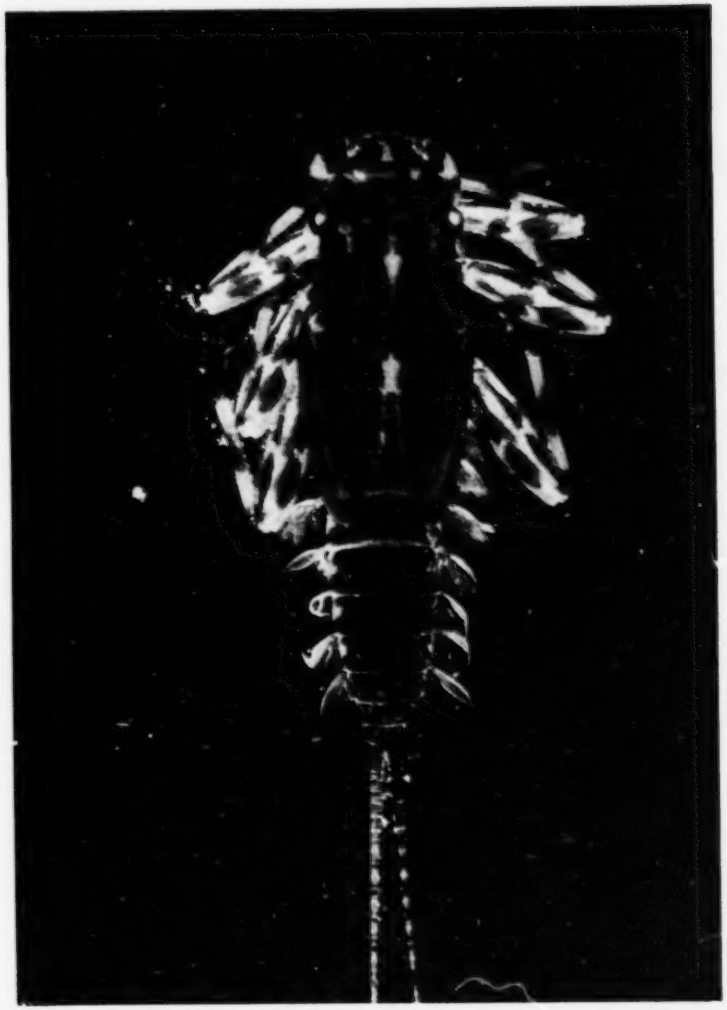

Fig. 1. Mayfly nymph with no Sphaerotilus growth. Sta. 4, October 5, 1961.

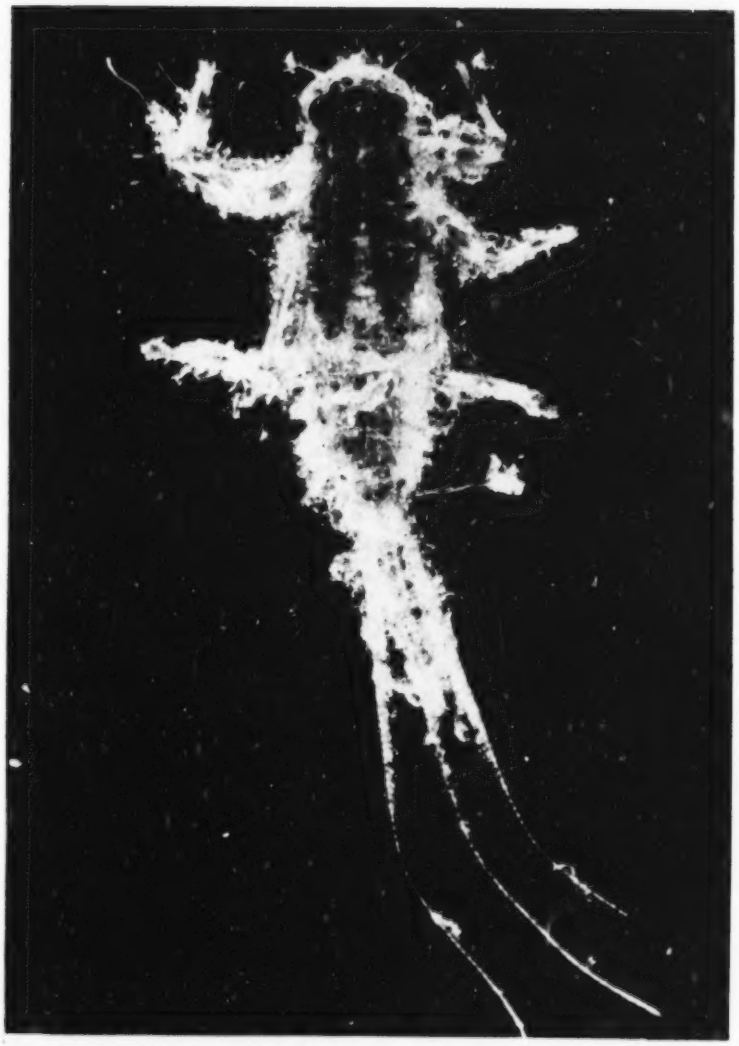

Fig. 3. Mayfly nymph with heavy Sphaerotilus growth. Sta. 4 October 14, 1961.

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is no assurance that it did not occur earlier in the season. Bottom organisms were covered with fine silt soon after the start of beet processing in October, 1961, and it seems reasonable to assume that some mortality resulted from this action in 1960 and 1961. Silt entering from irrigation drains in late summer 1961 did not have this effect.

Study of Table 2 will show that benthos was greatly reduced in some reaches where it still persisted at the end of October 1961. The left bank of the river below Torrington was considerably more affected by waste discharges in 1961 than in 1960. Disappearance of benthos from this reach and in the vicinity of the Gering - Mitchell diversion dam may have occurred before January 1, 1962. Complete loss of benthos at Mitchell and West Scottsbluff appeared less likely.

Fishes

In November, 1960, fishes generally avoided areas coming under influence of sugar beet wastes in the reach immediately below Torrington, but no indication of fish reactions could be gained below Station 3. Collections made by the Wyoming Game and Fish Commission in October, 1957 showed definite avoidance of waste-laden water by most piscine species. Fishes occurred in all river reaches visited in late summer 1961, and it appeared that they, like the benthos, were forced from many areas during seasons of beet factory operation. There were no evidences of fish mortality in 1957 and 1960, and it was assumed that they moved out of the above areas as conditions became intolerable, probably migrating into drains and other tributaries in those regions where wastes spread over the entire river. It was recognized that knowledge of the abode of fishes during fall and winter would add considerably to understanding of pollutional effects, and arrangements were made for a cooperative study by the Wyoming Game and Fish Commission, the Nebraska Game, Forestation, and Parks Commission, the Nebraska Department of Health, and the U. S. Public Health Service. Field collections and observations were made over the period October 30 - November 1, 1961.

Observations by Mr. Jack R. Geckler, U. S. Public Health Service, over the period October 4 - 14, 1961, indicated that fish again avoided waste-carrying water below Torrington and at Stations 3 and 8. He noted great numbers of fish crowded into a small clear drain at Bridgeport.

Fishes secured at each station with a DC electro-shocking rig over the October 30 - November 1 period are indicated in Table 3. Accurate quantitative estimates of fishes are difficult to secure by this or

Table 3.
Distribution and Relative Abundance of Fishes
In the North Platte River
Torrington, Wyoming to Bridgeport, Nebraska
October 30 - November 1, 1961

	Sta. 1	Sta. 2L	Sta. 2R	Sta. 3	Gering -[1] Mitchell Ditch	Sta. 4	Sta. 6	Sta. 7 R. Channel	Sta. 7[2] L. Channel	Sta. 8	Sta. 9 Edge of N. Chan.
Gizzard shad											
Brown Trout	R						R				
Rainbow Trout		R*									
Carp Sucker	R										
Long Nosed Sucker	A	A	C	A	A	C	R	A	R	R	
Western White Sucker	A	A	C	A	A	C	R	A	R	R	R
Northern Red Horse	C		R	C							
Carp	C	A		A	A	A	R	A	R	R	C
Long nose Dace	C	C	R		C	R	R	C	R		
Northern Creek Chub	A	A	C	A	A	C	R	A	R	R	C
Brassy Minnow	R			R		R	R	A	R		R
Red Shiner	C								R		
Sand Shiner	C	C	R	C		R	R	R	R	R	
Common Shiner	R	R		R	A	R			R		
Fathead Minnow			R								R
Stone Roller	R	R						R	R		
Stonecat		C			C						
Black Bullhead	R										
Banded Killifish				R				C		R	R
Plains Top Minnow											R
Green Sunfish	R										
Black Crappie								R			
Largemouth Black Bass											
Yellow Perch	R							R	R		

*One specimen from center
A=abundant
C=common
R=rare

[1]Isolated from river, gate closed

[2]Main channel

Table 3.
Distribution and Relative Abundance of Fishes
In the North Platte River
Torrington, Wyoming to Bridgeport, Nebraska
October 30 - November 1, 1961

	Sta. 9 Along Center Towhead	Sta. 9 Ditch by Sugar Beet Beet Disposal Area	Sta. 10 Right Bank	Sta. 10 Drain 1	Sta. 10 Drain 2	Sta. 9 Wild Horse Drain Near Bayard	Drain (Nine Mile?) Near McGrew
Gizzard shad			C	C			
Brown Trout			R	C		A	
Rainbow Trout							C[3]
Carp Sucker				R			
Long Nosed Sucker					C	A	A
Western White Sucker	C	C	C	C	C	A	A
Northern Red Horse	R	R					
Carp	C	C	A	A	C	A	A
Long nose Dace				C		C	
Northern Creek Chub	C	C	A	A	C	A	A
Brassy Minnow	R		C	A	C	C	R
Red Shiner				C	C	C	C
Sand Shiner	R	R	R	C	C		R
Common Shiner							
Fathead Minnow				C	C		R
Stone Roller							
Stonecat							
Black Bullhead				R			
Banded Killifish	R		R	C	A		
Plains Top Minnow							
Green Sunfish				R	R	R	
Black Crappie							
Largemouth Black Bass				R			
Yellow Perch							

[3] A number of large specimens, > 4 lbs.

other methods that take live specimens. The same length of shoreline (300') was covered at each locality, and fish are designated as rare, common, or abundant, with respect to their concentration along such distances. Exact numbers and weight of fishes were not recorded, and all specimens, other than small numbers retained for record, identification, and stomach analysis, were returned to the river alive. Collections were made in what appeared to be the best fish habitat at each locality. At the majority of stations fish were found only in the immediate vicinity of the river banks, and in some localities were restricted to small seeps or inflows that formed minor clear water areas at the margins.

Twenty-four species were found in the entire sampled reach. The greatest number of species found at one locality was 16 at Station 1. Fifteen occurred in Drain 1 at Station 10. Neither water area suffered any deleterious pollutional effects at the time of these collections. Number of species declined rather rapidly in the river below Station 1. Station 2L was somewhat affected by beet wastes (water was turbid and suspended pulp fiber common), but Station 2R carried most of the Torrington factory discharge. Fishes in 2R could easily retire to better conditions left of center (Station 2L). Most fishes at Station 3 (8 species) were aggregated in clear water in a side channel just below the diversion dam --very few occurred in the river below the control channel. Those present in the upper end of the Gering - Mitchell Ditch were trapped between the gate and a dry area about 200' downstream. This was not a situation conducive to a very varied fauna. At Station 4, 8 species of fish were found along the right bank, where some clear water retreats were available. Station 6 collections came from along the margin of the main flow path; no clean water refuges were near at hand, and fish were widely scattered.

The right channel at Station 7 carried a small percentage of total flow, largely from the gravel pit, and its most noticeable evidence of pollution was a comparatively moderate level of turbidity. Its fish population was as concentrated as any found in the river, but very few fishes occurred in the left channel, which carried most of the discharge and by far the greater part of the waste load. Surprisingly, each channel had the same number of species, eleven, but not all the same species. At Station 8, fish were found only in a narrow channel along the right bank, and their numbers were quite low. Fish survived conditions in the north channel at Station 9, which carried a poor quality effluent from the Bayard sugar plant waste treatment area, by crowding into a small patch of clear water entering from a seepage area. They were also rare along a towhead near the stream center. The ditch receiving effluent from the broad field beet waste disposal area had few, if any, escape niches of clean water. Two clear water drains at Station 10 (Drains 1 and 2) held considerable concentrations of fishes, and appeared to be havens from which fishes could move out along the adjacent river shoreline. Concentration in these drains was much greater than that noted anywhere in the river. It might be argued that gizzard shad at Station 10 indicated considerable waste amelioration, as these fishes are usually unable to endure organic wastes, but their existence in that region may have been assured by the proximity of clean water in the two drains.

Two larger clear drains, Wild Horse near Bayard and Nine Mile near McGrew, held active, healthy fish populations containing considerable numbers of trout. Only brown trout were found in Wild Horse Drain, and rainbows alone were taken in Nine Mile. Variety of fishes in these drains was not as great as in those at Station 10, but they were not as suitable for killifishes and sunfishes.

Table 4 simplifies Table 3 by indicating at how many of the 18 sampling sites each species of fish occurred and also lists the observed ability of each to endure the beet wastes. It is not surprising to note that the most widespread forms were those with greatest tolerance for this type of pollution. Table 5 shows tolerance ranges represented at each station. Areas with no pollution had fishes representing all resistance levels from 0 to ++++. As adverse elements increased, tolerance ranges narrowed down to the more resistant levels. Thus it may be noted that poorest conditions for welfare of fish occurred in the ditch receiving the broad field effluent at Bayard, along the center towhead in the river at Station 9, and at Station 8. It does not appear wise to assume that waste elements deleterious to these organisms were most concentrated at the above sites as availability of clean water refuges greatly increased the survival rate and the apparent tolerance of some species. For example, observations indicated that wastes were as thickly concentrated at Station 2R as in the Bayard ditch, but at 2R fully half the river served as an escape area. Nearness of the two uncontaminated drains allowed occurrence of fishes of all tolerance ranges at Station 10. It is suspected that the one red shiner taken at 7L had earlier found a small clean area from which it was drawn to the anode of the electro-fishing rig.

The ability of fishes to move into adjacent refuges, and their freedom from Sphaerotilus and silting troubles gave them greater survival potential than was allowed the majority of benthic animals. However, conditions improved for fishes at Station 6 and 7R, where benthos appeared to have a good chance of survival on November 1, 1961.

Table 4.
Number of Localities Inhabited by Each Fish Species
And Degree of Waste Tolerance Exhibited by Each

Fish Species	No. Localities Where Found	Apparent Tolerance To Beet Wastes
Northern creek chub	18	++++
Western white sucker	18	++++
Carp	17	++++
Sand shiner	14	++++
Long nosed sucker	13	++++
Brassy minnow	11	+++
Long nose dace	10	+++
Banded killifish	7	+++
Red shiner	6	0
Common shiner	6	++
Fathead minnow	5	++
Brown trout	5	+
Stone roller	4	++
Green sunfish	4	++
Northern red horse	4	++
Yellow perch	3	+
Stonecat	2	0
Black bullhead	2	0
Rainbow trout	2	+
Carp sucker	2	0
Gizzard shad	2	0
Black crappie	1	+
Largemouth black bass	1	0
Plains top minnow	1	++

++++ very tolerant
0 intolerant

Table 5.
Pollutional Tolerance Ranges Shown By
Fishes Collected at Each Station

Station 1	0 -> ++++
Station 2L	0 -> ++++
Station 2R	++ -> ++++
Station 3	++ -> ++++
Gering - Mitchell Ditch	0 -> ++++
Station 4	++ -> ++++
Station 6	+ -> ++++
Station 7R	+ -> ++++
Station 7L	0 -> ++++ (0= one red shiner Otherwise ++ -> ++++)
Station 8	+++ -> ++++
Station 9*	++ -> ++++
Station 10	0 -> ++++
Station 10, Drain 1	0 -> ++++
Station 10, Drain 2	0 -> ++++
Wild Horse	0 -> ++++
Nine Mile	0 -> ++++

*Sugar beet waste disposal area ditch ++++ only

Along towhead +++ -> ++++

Food Preferences and Problems

Information on the food relationships of the fish population was sought through examination of the digestive tracts of the larger species and some of the most abundant minnows. Since feeding habits noted in Station 1 were repeated in Nine Mile and Wild Horse Drains, it may reasonably be assumed that food utilized at Station 1 was normal for the river at that season (October 30 - November 1, 1961). Organisms favored by each species examined were as follows:

Longnose sucker: attached algae and all organisms associated with it. The intestinal tracts of these fishes suggested that they were animated vacuum cleaners, sucking up green algae, diatoms, midge larvae, etc., and many grains of sand. Individuals six inches and longer were examined.

Western white sucker: mostly midge larvae, but also black fly larvae and pupae, caddis larvae, and mayfly nymphs. This species appears to seek out individual organisms. Digestive tracts held no algae, sand, or other extraneous material. Specimens examined were four inches or longer.

Northern creek chub: less than four inches, various small invertebrates, largely oligochaet worms; six inches and longer, smaller fishes.

Common shiner: algae exclusively.

Carp: algae, Potamogeton, and various benthic organisms included with algae. No sand or other extraneous material was observed. Size range four to ten inches.

Stone roller: algae exclusively.

Trout (brown and rainbow): smaller fishes

Brassy Minnow: algae in one specimen, all others empty. Size range two to four inches.

Northern red horse: all specimens empty. Size range four to eight inches.

Longnose dace: sand and detritus in one specimen, all others empty. Size range two to three inches.

Sand Shiner: none with food in stomach. Sizes examined two to three inches.

It is not assumed that the above food preferences necessarily hold true for all seasons.

Condition of fish stomachs at six stations where varied degrees of pollution existed is shown in Table 6. With the exception of small fishes, natural food was very scarce at all listed stations other than 2L, and it may be assumed longnose and white suckers at Station 2R obtained their food in 2L. Smaller fishes were present to some extent at all stations and carnivorous species were definitely favored in areas lacking algae and other benthic organisms. The number of empty digestive tracts at Station 3 and below suggests that the majority of species were unable to obtain food in most reaches influenced by sugar beet wastes. Some survival of plant life at Station 10 is suggested by Potamogeton in the stomachs of carp, but they may have fed in one of the two clear water drains. Drain 1, in which most fishes were concentrated at that locality, yielded no benthic organisms to collectors on November 2, 1961, and near extinction of its food resources was probably one stimulus behind the movement of fish out into the muddy river.

Table 6.
Condition of Fish Digestive Tracts at Selected Stations

	Sta. 2L	Sta. 2R	Sta. 3	Sta. 8	Sta. 9	Sta. 10
Longnose sucker	N	N	E	E	-	-
White sucker	N	N	N	E	E	E
Creek chub*	N	N	N	E	N	N
Common shiner	N	-	E	-	-	-
Carp	N	-	E	N**	E	N
Stone roller	N	-	-	-	-	-
Brassy minnow	-	-	E	-	-	E
Red horse	-	E	E	-	E	-
Longnose dace	E	E	E	-	-	-
Sand shiner	E	E	E	E	E	E
Rainbow trout	N	-	-	-	-	-
Brown trout	-	-	-	-	-	N

N = with normal food

E = digestive tracts empty

- = species absent or not examined

*N for this species = smaller fishes at 2R and below

**One Sphaerotilus covered mayfly nymph

Some white and longnose suckers taken at Stations 3, 8, 9, and 10 were in poor condition, but other species had not lost noticeable amounts of flesh. Trout found in polluted situations (Stations 2 center, 6, and 10) had recently fed upon smaller fishes and were well fleshed. The rainbow from near center at Station 2 was unpleasantly soft and retained finger pressure marks for a few seconds. Trout in Wild Horse and Nine Mile Drains seemed in good condition.

Welfare of fishes in reaches of the North Platte River contaminated with sugar beet wastes seemed largely dependent upon the presence of various sized clean water areas in which they could find refuge from time to time or continuously as conditions demanded. Fishes were captured along shore in most areas, and it is suspected that numbers of them were drawn from minute clear water seeps at most polluted stations. This was demonstrably true along the north channel at Station 9. Food supply of most fishes was definitely curtailed or eliminated, and they may have suffered from physical contact with the waste elements. Fish food organisms suffered direct and indirect damages from the waste complex, and Sphaerotilus growths, which proved lethal after attachment to bottom animals, also seemingly rendered areas of bottom unfit for grazing by herbivorous fishes. Longnose suckers were apparently unable to secure any food on bottoms coming under influence of the factory discharges. Trout, which appeared to be the only sport fishes with any potential in this river reach, generally avoided waste-laden water. In their case, direct physical waste effects appear more suspect than food shortage, as their normal autumn food, smaller fishes, survived in all reaches.

The red shiner, stonecat, black bullhead, carp sucker, and gizzard shad appeared unable to long endure contact with the wastes. Only one specimen of large mouth bass was found.

DISCUSSION

Permissible evaluations of biological damage at this time must relate to the fish population and its basic food organisms. Restriction of fish habitat and reduction or elimination of their elementary food resources were clearly demonstrated. Important areas in fish food relationships that still remain blank are the feeding habits of the smaller minnows (eaten by trout and chubs) and length of starvation period that can be endured by suckers and other herbivorous and insectivorous fishes. Past observations indicate that most blanketing elements originating in the beet wastes are moved on downstream, and recovery of algal growth could be expected soon after close of beet processing. It may reasonably be assumed that herbivorous fishes spread out into the river at that time, even if they are somewhat benumbed by cold water. Fishes normally seeking insects and other invertebrates may still have difficulties, but they may change diets or benefit from a new crop of midges. This is largely speculative. Fish metabolic rate may be low enough in winter to permit extended survival on stored reserves with little or no food intake, or substantial percentages of the population may perish.

Overcrowding of clean drains places great increase in demands on their food supplies, and carrying capacity of such situations is reduced in relation to the extent of overpopulation. Trout habitat is considerably impaired by the wastes, and its potential for expansion appears limited with present operational procedures at the beet plants. All fishery resources are undoubtedly damaged and recovery of habitat and food supply is only partial in the interval between beet campaigns. Much more varied biotas would be developed if annual destruction by beet wastes could be avoided.

SUMMARY

1. Sugar beet wastes put into the North Platte River at Torrington, Wyoming in late October and early November, 1961, contained less suspended sediment and beet parts than they exhibited in November, 1960. No fresh accumulations of beet pulp and other fragments were noted anywhere on the bottom in the Torrington to Bridgeport, Nebraska reach.

2. Effects of these wastes upon the stream's biota, however, were nearly identical to those noted in 1960. Attached algae and bottom animals were eliminated or severely reduced along the course of waste-laden water, and fish concentration in such areas became quite low. Beet wastes turned into the river in the Scottsbluff, Nebraska area and at Bayard, Nebraska, induced the same general conditions. Pollution originating in the Mitchell, Nebraska beet plant had less severe effects at a station 5.3 miles downstream, but it appeared that some amelioration was accomplished by detention of part of the waste load in an old gravel pit.

3. Survival of fishes was aided by their migration into clean water drains or other tributaries and their retirement into small clear water areas formed by marginal seepage. Food for most species posed quite a problem in areas where benthic algae and animals had been eliminated, or where Sphaerotilus growths invested surviving algae. With few exceptions, benthos feeding fishes had empty digestive tracts in the reach between Station 3 and Bridgeport.

4. The filamentous bacterium Sphaerotilus was greatly stimulated by the elements in the beet factory discharges. It replaced algae on large areas of bottom and its detached fronds and clumps formed a large share of materials carried in suspension. It also became attached to various bottom animals.

5. Mortality of benthic animals was occasioned by enveloping growths of Sphaerotilus that fastened upon them, and by smothering effects of fine silt deposited by the beet wastes. Algae were eliminated by silting, turbidity induced light reduction, and possibly by competition with Sphaerotilus. They were often blanketed by the bacterium. Benthic animals were eliminated or greatly reduced within thirty days after start of the beet campaign.

6. The fish population clearly suffered restriction of habitat and severe or total reduction of food resources. The only important game fishes, trout, were largely restricted to clear water drains or areas adjacent to the mouths thereof. Only carnivorous fishes enjoyed a stable food supply in the river, and the existence of their prey was threatened by shortages of algae and bottom animals. The full extent of damage is impossible to assess from data now available. The sport fishery was restricted and most of the Torrington - Bridgeport reach was taken out of production of basic fish food organisms. Crowding of fishes into drains and other clean water areas undoubtedly reduced the carrying capacity of such habitats.